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SIMULTANEOUS AND SUCCESSIVE DISCRIMINATION

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In a recent experiment by Weise and Bitterman (12) the relative difficulty of simultaneous and successive discrimination was studied. A four-unit apparatus of the alley-maze type was employed, with two small lamps mounted at each choice point. One group of rats was trained on the simultaneous problem (i.e., turn in one direction when the right-hand lamp is on and in the opposite direction when the left-hand lamp is on) and a second group was trained on the successive problem (i.e., turn in one direction when both lamps are on and in the opposite direction when both lamps are off). The first problem proved to be much more difficult than the second, a result of considerable theoretical interest.

As Weise and Bitterman noted, the influential theory of Spence (8) was unable to account for the fact that the successive problem could be learned at all. Furthermore, a logical extension of the theory in accordance with the Hullian principle of afferent neural interaction (4), while making an explanation of successive learning possible, would lead to the deduction that the successive problem should be more difficult than the simultaneous. The Weise-Bitterman paper led Spence to modify his theory in the manner anticipated (9).[1] At the same time he reported the results of a new experiment with a simple elevated T maze (gray stem and black or white arms) in which the simultaneous problem was found to be considerably easier than the successive. Spence emphasized the correspondence of the new results with his extended theory and dismissed the contradictory data in an offhand manner: "Just why Weise and Bitterman got opposite results is not clear, as it is difficult to interpret the very complex type of discrimination set-up they employed. The simple discrimination situation is sufficiently difficult to deal with theoretically without adding all of the problems that arise as the result of the serial nature of the multiple discrimination set-up along with the fact that it involves a gradient of reinforcement" (9, p. 91).

Weise and Bitterman noted also the bearing of their data on the validity of Nissen's (5) attempt to subsume all discriminative behavior under the general headings of approach and avoidance. Nissen had deduced that the successive problem should be more difficult than the simultaneous problem since the former requires the development of conditional reactions or stimulus-compounding, a deduction which seemed to follow logically from a literal approach-avoidance theory. In a subsequent commentary on the Weise-Bitterman experiment, however, Nissen (6) denied that its results had any bearing on the validity of his formulation and attributed his deduction to the "misplacement" of a sentence. From this paper it became clear that Nissen's conceptual scheme was so broad as to be incapable of experimental evaluation (1).[2] Nissen did,

[1] Successive discrimination was explained in terms of compounding and was assumed, therefore, to be more difficult than simultaneous discrimination. For an evaluation of the extended theory, see Bitterman (2).

[2] The test which Nissen himself performed (5) is deprived of conclusiveness by his analysis of the Weise-Bitterman experiment. Animals were taught a simultaneous white-black discrimination with the stimuli horizontally

nevertheless, make one important criticism of the Weise-Bitterman experiment. He suggested that the less rapid learning of the simultaneous problem might have been due to reduction of the bright-dark difference by reflected light. From this point of view, Spence's contradictory results might be attributed to his use of painted stimuli rather than to the simplicity of his method.

These considerations led us to perform further experiments on the relative difficulty of simultaneous and successive problems with the conventional jumping apparatus. That situation should be simple enough to meet the requirements of Spence's theory, and the use of painted stimulus cards should avoid the criticism of the Weise-Bitterman apparatus which Nissen proposed. An as yet unpublished doctoral dissertation of E. F. MacCaslin provided evidence in support of the prediction by Weise and Bitterman that the relative difficulty of the two problems would depend on the similarity of the stimuli to be discriminated; [3] however, while the successive problem proved to be much more difficult than the simultaneous problem when difficult discriminations were employed (e.g., two vertically striped cards differing in stripe-width), even with simple discriminations (e.g., horizontally vs. vertically striped cards) the simultaneous problem was somewhat easier than the successive. In a subsequent experiment by Bitterman, Calvin, and Elam (3) with a discrimination between two circles markedly different in diameter, successive and simultaneous groups performed in almost identical fashion,[4] but in no experiment did we find superior performance in the successive group.

These results led us to reconsider the earlier interpretation of the Weise-Bitterman data. Another look at the maze apparatus made Nisson's explanation in terms of reflected light seem unlikely, and Spence's comment on complexity did not seem to further our understanding of the contradictory results—why the use of a multiple-discrimination apparatus should affect the relative difficulty of the two types of problem was not clear. Upon further consideration, however, another interpretation of the divergent results occurred to us. Weise and Bitterman assumed that their successive problem had been mastered on a configurational basis—its relative simplicity led them to reject the idea of compounding or conditional discrimination in favor of the assumption that the animals had learned merely to make one response to the bright configuration and an opposed response to the dark—but they expressed some doubt as to how the simultaneous problem had been solved: "If learned configurationally, the greater difficulty of the simultaneous problems may be attributed to the greater similarity between the two stimulus-patterns

arranged and later tested with a vertical arrangement of the same stimuli. Had there even been zero transfer, Nissen could have dealt with the results by assuming that the animals had learned to "approach" and "avoid" brightness-position compounds which were disrupted by the shift in the locations of the stimuli.

[3] Nissen was unkind enough to suggest that this prediction was made in anticipation of "the possibility of experimental evidence inconsistent with" the position of Weise and Bitterman (12, p. 164). Actually, the prediction followed logically from the data of Saldanha and Bitterman (7) on relational learning.

[4] In this experiment the simultaneous group had previously learned a simultaneous problem (horizontal vs. vertical stripes) while the successive group had been trained on a corresponding successive problem. For naive animals trained by MacCaslin on the circle discrimination, the simultaneous problem was somewhat easier. These studies point to the operation of qualitatively distinct perceptual sets in the two types of problem.

which it presented to the animal. . . .[5] If mastery was based on the acquisition of functional properties by afferent components, this kind of learning may be assumed to involve a more complex, higher order process" (12, pp. 192–193). Although Weise and Bitterman were led to emphasize the second interpretation, the experiment of Spence and our later studies with the jumping apparatus required us to re-examine the first.

In the jumping apparatus the animals were required to jump directly at the stimulus cards, and in Spence's T maze the animals were required to enter upon the stimulus runways. These may be described as *approach* situations in the literal meaning of the word. The relative simplicity of the simultaneous problem in such situations can be explained on the assumption that they facilitate the functional isolation of the two members of each pair of stimuli. In the apparatus of Weise and Bitterman, on the other hand, the two stimuli (lamps) at each choice point were closely juxtaposed and the animals were required to turn away from them, to one side or the other, in making their way through the maze. This may be described as a *response* situation. It facilitates configurational organization and thereby retards the functional isolation of the two members of each pair of stimuli. From this point of view the greater difficulty of the simultaneous problem is understandable either in terms of the greater similarity of its two configurations (on the assumption that solution is based on configurational discrimination) or in terms of the difficulty of perceptual analysis in such situations (on the assumption that solution is based ultimately on response to components). This interpretation, like Weise and Bitterman's, proposes two qualitatively distinct types of perceptual organization in these problems, but the functional priority of configurational perception is not postulated. Instead, it is assumed that the dominance of one or the other kind of organization is determined by the physical characteristics of the apparatus employed.

The experiment to be reported was designed to test the hypothesis that the Weise-Bitterman results were due to the fact that their apparatus—presenting closely juxtaposed stimuli which the animals were not required to approach directly—favored configurational organization. To distinguish between this interpretation and those of Spence and Nissen, it was necessary only to reproduce the essential features of the Weise-Bitterman situation in a suitably modified jumping apparatus.[6]

METHOD

Thirty experimentally naive Albino rats bred in the laboratory were studied. They were between three and four months old at the start of the experiment. After adjustment to handling, the animals were placed on a 24-hr. feeding schedule and preliminary training in the apparatus was begun.

The jumping apparatus was designed in the conventional way with only one exception. The two windows to which the animals were to jump were separated by a center window which was used only for stimulus cards (Fig. 1). The three windows were cut in a hemihexagonal surround which was painted gray. Behind the windows was a feeding platform to which the animals gained access following a correct response, and below the windows

[5] It was this statement that Nissen (6) apparently confused with his own analysis in terms of reflected light. Weise and Bitterman were merely noting the obvious fact that the configurations *dark-light* and *light-dark* are more similar than the configurations *dark-dark and light-light*. That this difference is independent of the stray-light problem the present experiment (with painted stimuli) will demonstrate.

[6] We are indebted to Mr. Richard Gonzalez for assistance in the conduct of this study.

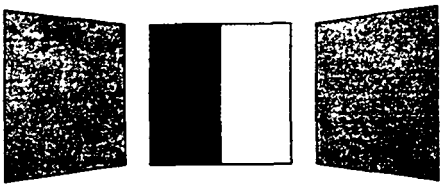

FIG. 1. Rat's view of the stimulus card (center) and response windows. The stimulus card shown was used in the simultaneous problem, in which the animal's task was to jump to one of the gray cards when the white area was on the right and to the other gray card when the white area was on the left. In the successive problem the stimulus card was either all white or all black, the white card signalling response to one of the windows and the black card to the other. The three windows in which the stimulus and response cards were set were cut in a hemihexagonal surround.

was a cloth net into which the animals fell after an incorrect response.

During preliminary training a gray card was locked in the center window, and the animals were trained to jump gradually increasing distances (up to a maximum of 9 in.) through the open left and right windows. Then they were trained to jump to unfastened gray cards (somewhat darker than the gray of the background to facilitate localization) in the left and right windows. Manual guidance was used to ensure equal experience with both windows. Following the preliminary training the animals were divided into two groups of 15 animals each which were matched for adjustment to the situation.

Group I was trained on the simultaneous problem and Group II on the successive problem. For both groups the gray cards used in the preliminary training appeared in the lateral windows on each trial. The center window, which contained the stimuli to be discriminated, was locked at all times as before. Group I was trained with a stimulus card which was half black and half white (Fig. 1). Seven of the animals in this group were rewarded for jumping to the right window when the white half of the card was on the right (black-white configuration) and to the left window when the white area was on the left (white-black configuration). The direction of correct response was reversed for the other eight animals of Group I (left to black-white and right to white-black). Group II was trained with two stimulus cards, both halves of each being either black or white. Seven of the animals were rewarded for jumping right to white-white and left to black-black, while the direction of correct response was reversed for the remaining eight animals of Group II (left to white-white and right to black-black). Ten trials per day, five to each of the two configurations of each problem, were given by the correction method. Each animal was allowed a maximum of three free jumps on each trial, and after three successive errors it was manually guided in the correct direction; a correct jump terminated each trial. The criterion of learning was one errorless day.

RESULTS AND DISCUSSION

The course of learning in the two groups is plotted in Fig. 2 (initial errors) and Fig. 3 (total errors). In Table 1 the results are summarized in terms of mean errors and days to criterion. The difference between the two groups was large and statistically significant for all measures. The direction of the difference was in accord with that found by Weise and Bitterman—the performance of the successive group being markedly superior to that of the simultaneous group—and there was as little overlap between the two groups in the present experiment as in the earlier

TABLE 1

RELATIVE DIFFICULTY OF SIMULTANEOUS AND SUCCESSIVE PROBLEMS

	I Simultaneous	II Successive	*Diff.**
Days	14.0	7.9	6.1
Initial errors	50.7	25.2	25.5
Total errors	80.9	40.1	40.8

* All differences were significant beyond the 1% level of confidence by Wilcoxon's nonparametric test for unpaired deviates (13).

one. Thirteen of our successive animals reached the criterion of learning before the first simultaneous animal had done so, while in the earlier experiment 9 of the 10 successive animals reached criterion before the first simultaneous animal.

Although the present experiment confirms the results of Weise and Bitterman, accumulated evidence requires a new interpretation of those results. As we have seen, Weise and Bitterman assumed that their simultaneous problem represented a simple within-pairs differentiation, and on this assumption the greater simplicity of the successive problem was taken as evidence for the relatively primitive nature (defined in terms of priority or dominance) of configurational perception. It now seems likely that *both* the Weise-Bitterman problems were configurationally organized, at least to begin with, and that the difficulty of the simultaneous problem was due to the greater similarity between the configurations of that problem or to the fact that those configurations could not be readily differentiated into components. In situations such as Spence's T

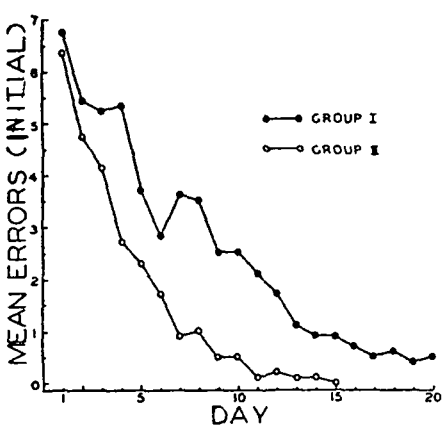

FIG. 2. The course of learning in the two groups plotted in terms of mean initial errors per day. Group I learned the simultaneous problem and Group II the successive problem.

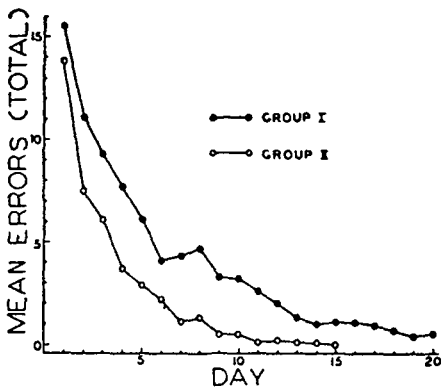

FIG. 3. The course of learning in the two groups plotted in terms of mean total errors per day. Group I learned the simultaneous problem and Group II the successive problem

maze or the conventional jumping apparatus, which require the animals to approach (jump at or enter upon) the stimuli more directly, internal differentiation of simultaneous configurations is more readily achieved, and the simultaneous problem seems to be less difficult than the successive. Configurational effects may, nevertheless, operate in such situations (3, 14), and under specialized conditions, such as "two-situational" problems in which between-pairs differences are great and within-pairs differences are small, configurational organization may predominate (10, 11). At the present time the emphasis of Weise and Bitterman on qualitatively distinct levels of perceptual organization seems to be justified; unfortunately, however, the precise nature of these processes, their interrelations, and their hierarchical arrangement on a scale of priority remain in considerable doubt.

When the results of Spence and those obtained with the conventional jumping apparatus are contrasted with the results of Weise and Bitterman and those obtained in the present experiment, the value of a more restricted definition of the concept of *approach* is indicated.

If this term is used so loosely as to apply to behavior in all discriminative situations, no basis is provided for understanding the contrary results obtained in the two groups of experiments. As long as an animal is locomoting, it can be regarded as "approaching" something in its path and "avoiding" something not in its path; [7] such designations at best contribute nothing to our understanding and at worst may carry misleading implications concerning perceptual-motor relationships. If we look toward a more literal definition of approach-avoidance situations (perhaps in terms of the consequences of direct contact with stimulus objects), we have a basis for distinguishing at least two different classes of problem which seem to produce divergent results.

SUMMARY

The Weise-Bitterman experiment on the relative difficulty of simultaneous and successive discrimination has been criticized for complexity of method and failure to control stray light. In the present experiment, which was designed to forestall these criticisms, the Weise-Bitterman results were reproduced with a jumping apparatus. These and other recent experiments suggest the following conclusions: (*a*) in apparatus which require the animal to approach directly (jump at or enter upon) the stimuli to be discriminated, within-pairs differentiation is facilitated and the simultaneous problem is less difficult than the successive; (*b*) in apparatus in which the stimuli are closely juxtaposed and need not be directly approached, configurational organization is facilitated and the simultaneous problem becomes more difficult than the successive; (*c*) the qualitative distinction between relational (within-pairs) and configurational (between-pairs) discrimination continues to be applicable although the question of functional priority cannot be answered in general terms; (*d*) if the concept of approach-avoidance is to be useful, its definition must be considerably restricted.

[7] Nissen (5) has even extended the meaning of the terms to cover the appearance and nonappearance of "tail-twitching."

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